RESEARCH CLUSTER M
Mechanics & Advanced Manufacturing of Polymers and Composites

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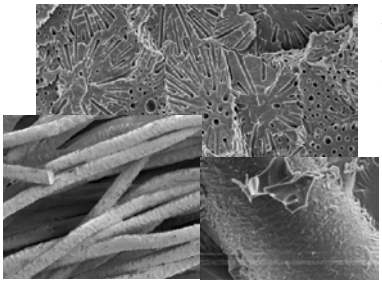
Overview

This Research Cluster focuses on understanding structure-process-property relationships of next-generation materials together with the development of new process methods and/or additives that simultaneously improve processability and engineering properties. Use of commercially available materials to generate new materials and products with enhanced properties and performance is emphasized, as is development of environmentally benign and sustainable technologies for next-generation product fabrication.

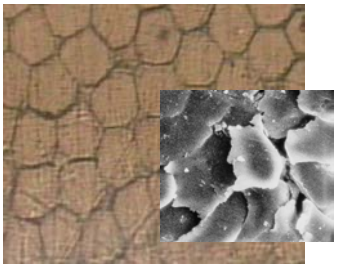
Processing Polymers in Superheated Water and Oher Liquids

Research related to understanding and exploiting dramatic changes in properties of polymers that occur under conditions of high temperature and pressure in water and other polar liquids. Such processing conditions can be utilized to solvate and process many intractable polymers, including, for example, polyamides, polyethersulfones, polyphenylene ether, polyetherimides, etc., and thereby provide new methods for creating novel nanocomposites, microcellular foams, foamed films and fibers.



Fabricating Composites in Supercritical Carbon Dioxide (scCO2)

This research utilizes scCO2 as a transport, reaction, process, and/or foaming medium to create complex and novel advanced composite systems comprising polymers, alloys, blends, fibers, etc. The example result shown illustrates a composite where the selected polymer was grown inside of a nylon 6,6 fiber and across the interface to produce a composite material with unusual properties. Process studies on candidate composite materials will utilize a specially modified twin screw extruder capable of continuously processing materials in scCO2 mediated environments, as well as other bath reactors that allow more fundamental characterization of the thermodynamic state of new compositions.



Self-Reinforcing Composites

Research related to selecting crystallizable low-molecular weight additives, which at process temperatures become miscible with the polymer/momomer, thereby lowering the process viscosity. Upon cooling or *in situ* reaction, the compounds are engineered to phase separate and re-crystallize to generate structural reinforcement. The relative kinetics can be tuned with process conditions to generate reinforcement ranging from nano-crystalline to large fiber-like reinforcement. The example result shows an amine cured epoxy thermoset reinforced with a crystalline compound, resulting in highly anisotropic reinforcement formed under quiescent conditions.

New Characterization Methods

Unique specialized characterization methods are used to evaluate optimum performance characteristics of engineering materials. These methods allow for direct/efficient measurements of polymer characteristics critical for high performance applications. These include nonlinear properties comprising impact, fracture, and long-term performance during exposure to a variety of environmental conditions. These include:

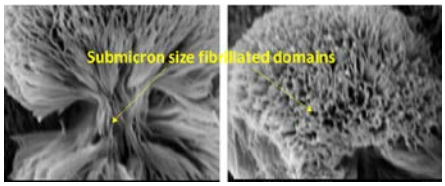
- High pressure dilatometry
- Biaxial stress relaxation
- ESC Resistance measured via laser diffracted contact angle

High Pressure Dilatometer

This instrument is designed to evaluate transitions and other mechanical and thermodynamic properties of solids and liquids, including bulk modulus, volumetric coefficient of thermal expansion and pressure induced crystallization and melting. The instrument can achieve maximum pressures of 138 MPa with better than 1 microliter precision in volume.

Additional Research Initiatives

Melt-Mastication: A new process method for semi-crystalline polymers to generate ultra-high crystalline polymers.



Pre-stressed double network glasses:
A new fabrication method to generate transparent glasses with superior impact resistance via incorporation of a second network in a pre-stressed glass.

Next-Generation 3D printing formulations:
The focus in this effort is to generate resins that have superior interfacial strength and enhanced sintering or reaction kinetics.

Contact Information

To participate in a CUMIRP Part I research cluster please contact:

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